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B70 09004

SUBJECT: Skylab B Experiment Program
Rationale - Case 105-4

DATE: September 1, 1970

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ABSTRACT

Astronaut involvement in the conduct of manned space experiments should be increased over the levels planned for Skylab A. Four candidate experiments for a Skylab B payload are described to indicate how the astronauts' presence could be used to greater advantage. Using an electron gamma ray experiment as one example, typical tasks are described which would use a range of astronaut capabilities in the conduct of the scientific experiment. Measures of in-flight task performance are suggested which could provide a planning base for the design and conduct of post-Skylab B experiments.

Our report is presented using vu-graph charts and supporting text. The vu-graph material was presented to members of the Advanced Manned Missions Program Office at NASA Headquarters in June, 1970. The authors are indebted to G. Briggs, L. Kaufman, R. Sharma, and F. Tomblin for their contributions.

(NASA-CR-86467) SKYLAB B EXPERIMENT PROGRAM
RATIONALE (Bellcomm, Inc.) 27 p

N79-71661

Unclassified

00/12 11870

FF No. 602

(PAGES)

(CODE)

CR-86467

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

MEMORANDUM FOR FILE

SKYLAB B EXPERIMENT PROGRAM RATIONALE

SKYLAB B EXPERIMENT PROGRAM PLAN

- DEMONSTRATE THAT MAN CAN SURVIVE IN SPACE FOR AT LEAST 90 DAYS; COLLECT DATA TO SUPPORT LONGER DURATION MISSIONS.
- EVERY EXPERIMENT MUST PRODUCE IMPORTANT, TIMELY DISCIPLINARY RESULTS.
- CANDIDATE EXPERIMENTS INCLUDE:

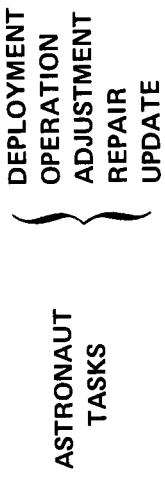
ELECTRON GAMMA RAY EXPERIMENT – QUALIFIES

MATERIALS PROCESSING – NOT YET ACCEPTED BY SCIENTIFIC AND INDUSTRIAL COMMUNITY

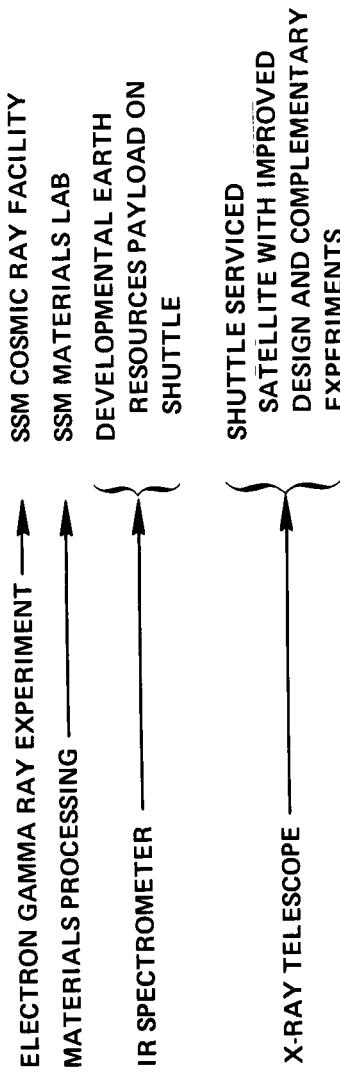
IR SPECTROMETER – COULD BE DONE ON SKYLAB A

X-RAY TELESCOPE – QUALIFIES

- UNTIL ASTRONAUT TIME AVAILABLE FOR EXPERIMENTS IS USED UP, EVERY EQUIPMENT CHOSEN MUST USE A FUNDAMENTAL MAN/INSTRUMENT OPERATION CAPABILITY. WHEN ASTRONAUT TIME IS GONE, ANY AVAILABLE WEIGHT AND VOLUME CAN BE USED FOR AUTOMATED EXPERIMENTS.



- EXPERIMENTS SHOULD BE FAVORED WHICH CONSTITUTE AN INTEGRAL PART OF AN EVOLUTIONARY PROGRAM.



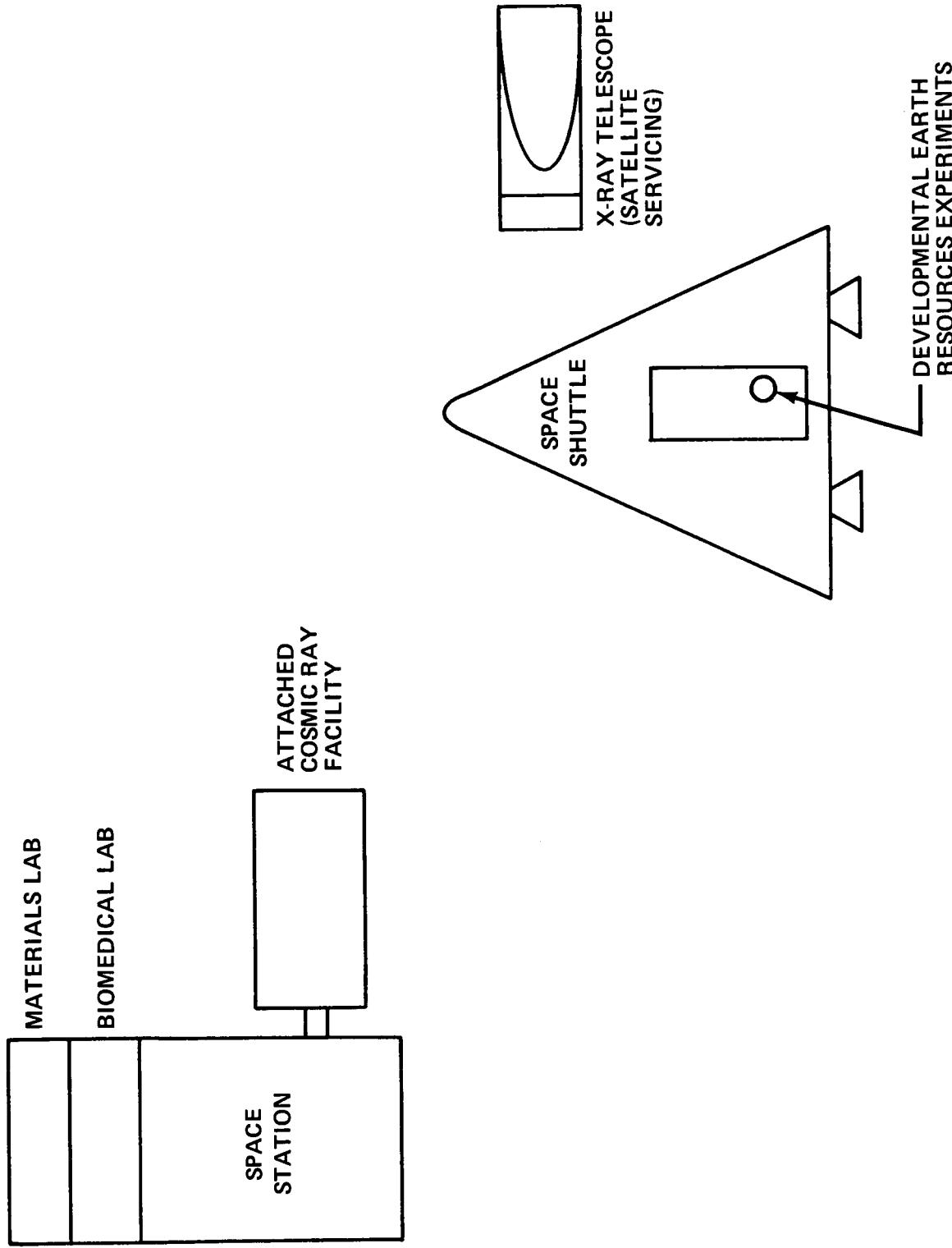
During an early phase of this study we reviewed the Skylab A biomedical program. It was concluded that if there were a subsequent Skylab B mission designed to serve, in part, as a transition to the Space Station, the biomedical program for such a mission should incorporate at least three changes into the basic Skylab A plan. These are as follows: (1) make as much of the biomedical experiment data as possible available for operational decisions during the mission (as opposed to storing it for post-mission analysis); (2) add a behavioral observation and analysis program; (3) improve the task performance program to include the observation and analysis of a more challenging (for the astronaut) and productive (for the scientific experiment he is performing) set of activities. The focus of this paper is the incorporation of item (3), the task performance program, as an integral part of the Skylab B program of science, applications, and technology experiments.

Four experiments have been selected as examples for study here, only one of which (the electron gamma ray experiment) is discussed in detail in the text. (Material on the other three is contained in the Appendix.) Experiments for the flight payload should be selected primarily for their disciplinary merits. The four experiments cited here should be considered as payload candidates singled out to illustrate certain points regarding astronaut task performance. Except for the IR spectrometer experiment already planned for Skylab A, no more than preliminary feasibility studies have been carried out.

Two of the experiments are, at this time, felt to qualify as contributing important and timely disciplinary results: the electron gamma ray experiment and the x-ray telescope. High energy astromony questions, which both of these experiments address, have been given high priority by the Astronomy Missions Board. A materials processing experiment is described here for contrast with the small degree of astronaut participation in the Skylab A materials experiment. However, it is not apparent that sufficient disciplinary interest in materials experiments exists outside NASA to recommend such an experiment at this time. The IR spectrometer was selected for discussion because (a) it exhibits several astronaut functions (e.g., observational techniques) which could also be important for other experiments (e.g., plasma physics), and (b) it provides an example of one form of quantitative task performance data. Its disciplinary value parallels the current national emphasis on earth applications. The experiment described here may have to be redefined for Skylab B if it is done successfully on Skylab A.

Compared to Skylab A, the Skylab B program should move in the direction of increased use of man for selected individual experiments. While it can be argued that all of the basic astronaut task functions listed here (deployment, operation, repair, etc.) may be exercised on Skylab A, the degree to which the experiment program employs these functions should be increased on Skylab B. Where possible, these astronaut tasks should be selected to provide information relevant to man/experiment interactions anticipated for future programs such as the Space Station Module (SSM) and Shuttle.

EXPERIMENT MODES WHICH COULD BE EXPLORED IN THE SKYLAB B PROGRAM



EXPERIMENT MODES WHICH COULD BE EXPLORED IN THE SKYLAB B PROGRAM

In the period following the introduction of the Space Station and Shuttle there will be three different modes to which experiments can be assigned:

- Satellites - no manned attendance
- Satellites - intermittent manned attendance based on commuting from the ground via the Shuttle or from the Space Station using, for example, the Space Tug
- Manned Vehicles - extensive manned attendance in laboratories or observatories on board the Space Station or Shuttle (in the case of the Shuttle, this could be a manned experiment module carried in the Shuttle bay)

The Skylab B program can be used to study operational aspects of the two modes involving man. For example, the x-ray telescope would be mounted external to the Skylab spacecraft and would be serviced using EVA. This would simulate a possible future mode for a follow-on x-ray experiment involving EVA servicing of a satellite-based telescope from the Shuttle. The electron gamma ray experiment would be carried inside the Skylab spacecraft for easy crew access. This could be the prototype for a cosmic ray facility flown as an attached module to a Space Station. The attached module would be an appropriate mode because only periodic manned attendance is anticipated, and the facility attitude control requirements are not so strict as to be incompatible with the capability of the Space Station.

Laboratory and observatory class experiments requiring more extensive manned attendance which could be done on Skylab B include materials processing and earth resources observations, respectively. Materials processing could occupy a special purpose laboratory on board a future Space Station. Earth resources experiments might be typical of part of a Shuttle payload flown for instrument development purposes, with the goal of defining a later operational experiment to be carried out on a satellite.

EXPLORING THE MAN-MACHINE INTERFACE

- A MAN CAN PERFORM ANY TASK IN SPACE HE CAN PERFORM ON THE GROUND IF HE IS PROPERLY SUPPORTED
- PROPER SUPPORT IS ACHIEVED OPERATIONALLY THROUGH GROUND-BASED SIMULATION AND INFLIGHT TASK PERFORMANCE OBSERVATIONS WHICH ARE USED TO IDENTIFY FAILURE MODES IN THE ASTRONAUT'S WORK SCHEDULE AND CIRCUMVENT THEM THROUGH EQUIPMENT RE-DESIGN AND/OR CHANGES IN PROCEDURE

EXPLORING THE MAN-MACHINE INTERFACE

The first statement on this chart suggests a working hypothesis to be used in the selection of experiments for the Skylab B payload. The second statement defines the role of task analysis, pointing out that there is both a ground-based and an in-flight phase.

In fact, we know that in the Apollo program astronauts have been successfully trained, mostly in ground simulators, to do a number of tasks in space. Most of these tasks have supported flight operations, and of these some (e.g., use of the sextant) have had direct analogs in the experiment program. Other tasks have been directed specifically at the experiment program. The Gemini and Apollo Programs have had some notable experiment successes. There have also been several failures, although this may reflect the fact that the amount of preflight training for experiment tasks has been subordinate to training for flight operations tasks.

As the earth orbital experiment program expands, it may not be realistic to operate every experiment in a ground simulator before flight. Until we have a much better understanding of man's experiment performance abilities in space, however, ground simulations should continue and task performance observations should be conducted in-flight as part of each manned experiment to provide a planning basis for improving the crew usefulness on subsequent flights.

EXPERIMENT DESIGN PHILOSOPHY FOR SKYLAB B

PREFLIGHT

- INSTRUMENT DESIGN SHOULD STRESS MAN'S INVOLVEMENT
- ASTRONAUT TRAINS FOR FAMILIARITY AND COMPATIBILITY WITH EACH INSTRUMENT AND PI
- CAREFUL SELECTION OF BACKUP AND SPARE EQUIPMENT IS CRUCIAL

IN FLIGHT

- EACH PI CAN COMMUNICATE WITH CREW DURING EXPERIMENT (FOR SOME EXPERIMENTS, REAL TIME ORBIT-TO-GROUND TV WILL BE NECESSARY)
- EACH EXPERIMENT PLAN DESIGNED TO PROVIDE SEVERAL LEVELS OF CREW/INSTRUMENT INTERACTION WITH PARTIAL SUCCESS POSSIBLE AT EACH LEVEL.
PERFORMANCE RESULTS AT ANY LEVEL CAN BE:

DISCRETE, eg, MIRROR POSITIONING	POSITIONED POSITIONED BUT SCRATCHED SHATTERED
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CONTINUOUS, eg, MIRROR ALIGNMENT

POST-FLIGHT

- DATA RETURN INCLUDES:
- SCIENTIFIC RECORD
 - LIST OF TASKS PERFORMED
 - QUANTITATIVE INSTRUMENT PERFORMANCE DATA
 - COMMENTS BY PI AND CREW

EXPERIMENT DESIGN PHILOSOPHY FOR SKYLAB B

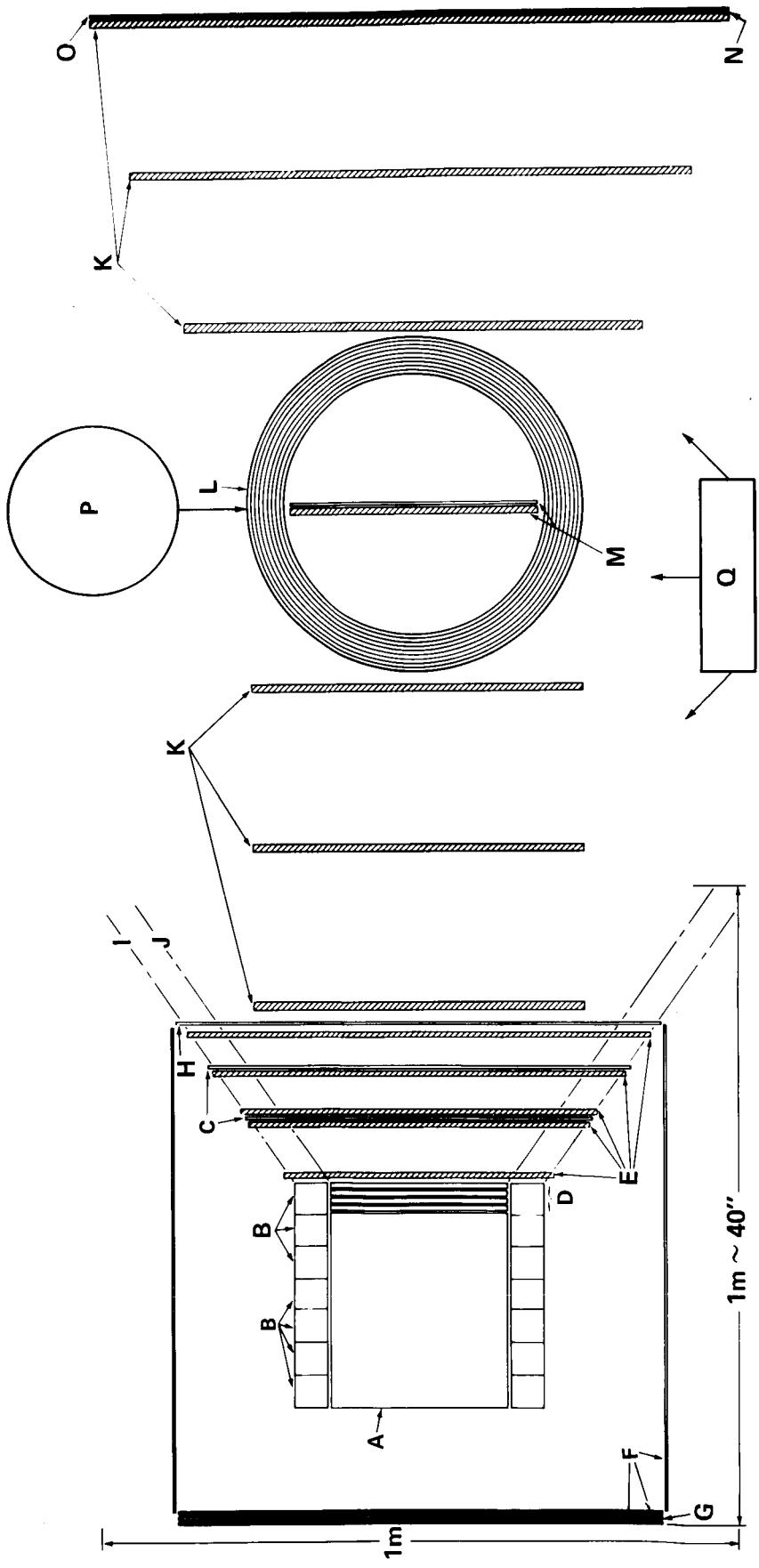
During the preflight phase astronaut training, possibly in simulators, can be used not only to become familiar with the instrument and effect design and/or procedural changes, but also to establish a rapport with the Principal Investigators with whom he may be working during the flight. From his knowledge of the instrument operation and expected astronaut capability, the PI may specify spare equipment to be carried for contingency purposes.

During the flight phase the PI may want real time TV communication with the crew during performance of his experiment. This would be one source of data for PI assessment of crew task performance.

Ideally, one would like to select and plan crew tasks such that if they are performed successfully, the experiment benefits; but if they fail, the experiment can still be a partial success. Our example of astronaut tasks for the electron gamma ray experiment will illustrate several such cases, although in practice all tasks may not permit this kind of backup. Tasks which have several possible levels of success are preferred because they are more likely to use the full task performance potential of the astronaut.

During the post-flight phase the task performance data from each experiment is analyzed. This data consists of a list of tasks performed with a corresponding record of scientific results as some measure of task success. Frequently, quantitative performance data is obtained as an inherent part of the experiment. For example, each IR spectrogram planned for Skylab A is expected to be accompanied by an optical photo to permit determination of where the area covered by the spectrogram lies relative to the target ground truth sight. Finally, comments by both the crew and the PI will be valuable in assessing instrument design and operation difficulties.

Based on the post-flight task performance data analysis, information could be transmitted to a new PI group to design an improved follow-on experiment.



HIGH ENERGY PHYSICS AND ASTRONOMY
AN ELECTRON GAMMA-RAY EXPERIMENT

SECTION I ~ 500 kg

- A. CsI (Na) CRYSTAL
- B. ANNULAR CsI (Na) CRYSTALS
- C. CsI (Na) CONVERTER
- D. CsI (Na) dE/dx CRYSTALS
- E. WIRE PROPORTIONAL CHAMBERS
- F. PLASTIC SCINTILLATOR
ANTICOINCIDENCE SHIELDS
- G. LEAD CONVERTER
- H. PLASTIC SCINTILLATOR FOR
 γ -e DISCRIMINATION
- I. ACCEPTANCE ANGLE (e^\pm)
- J. ACCEPTANCE ANGLE (γ)

SECTION II ~ 250 kg

- K. HIGH RESOLUTION TRACK CHAMBERS
($\Delta r \leq 10^{-4}$ m)
- L. FLAT SUPERCONDUCTING COIL,
 $B_c = 40$ Kg, $\int B \cdot dl \sim 20$ Kg-m
- M. REMOVABLE THIN-TARGET- TRACK
CHAMBER FOR e-N INTERACTIONS
- N. REMOVABLE THIN-TARGET
FOR γ -N INTERACTIONS
- O. PLASTIC SCINTILLATOR COINCIDENCE
COUNTER
- P. CRYOGENICS
- Q. ELECTRONICS SUPPORT

HIGH ENERGY PHYSICS AND ASTRONOMY
AN ELECTRON GAMMA RAY EXPERIMENT

The electron gamma ray experiment, which is one experiment in the disciplinary category of high energy physics and astronomy, has been selected as an example to illustrate some of the ways in which task performance analysis can be combined with a primarily scientific experiment. In particular, the following charts will illustrate a set of tasks which the crew should be able to perform. Basically, these are some of the same tasks a ground-based investigator (or technician) would perform if he decided to move his experiment from his laboratory to any remote operating site. The only requirement for post-flight task performance analysis is that when operational tasks are planned, appropriate means for collecting performance-related data (discussed with the previous chart) be provided.

The instrument configuration shown on this chart occupies approximately a $1 \times 1 \times 3$ meter volume and weighs about 750 kg. It consists of two basic sections. Section I contains a large crystal where particle energy is measured by observing photon production with an array of photometers. Section II is a magnetic spectrometer used to measure the momentum/charge ratio for charged particles. This is done by measuring the deflection of the particle path as it passes through the magnetic field. To determine this path the track chambers measure particle position at several places along its trajectory. These chambers consist of wire grids surrounded by gas. They respond to particle passage by locating the ionization created by particle interaction with this gas.

ELECTRON GAMMA RAY EXPERIMENT PLAN

- SCIENCE RETURNS (UNIQUE RETURNS IN THE ENERGY RANGE 10^9 – 10^{14} eV)
 - ELECTRON AND GAMMA-RAY FLUX ENERGY AND DIRECTION
 - e^\pm SEPARATION
 - ANTIMATTER DETECTION
 - ELECTRON-NUCLEON AND GAMMA-NUCLEON INTERACTIONS
- USE OF MAN
 - EXPERIENCE IS GAINED
 - USING MAGNETS ON SPACE PLATFORMS
 - HANDLING CRYOGENS
 - ALIGNING TRACK CHAMBERS
 - RECONFIGURING, REPAIRING, AND UPDATING
 - THERE ARE BOTH SIMPLE AND COMPLEX TASKS
 - UNPACK CRYSTAL
 - POSITION IT
 - ATTACH PHOTOMULTIPLIERS
 - UNPACK TRACK CHAMBERS
 - POSITION, ALIGN, AND CONNECT THEM
 - EXCITE MAGNET
 - REPLENISH CRYOGENS ON PERIODIC BASIS
 - CHECK ALIGNMENT ON PERIODIC BASIS
- EVOLUTIONARY POTENTIAL
 - REAL TIME INTERACTION BETWEEN THE SCIENTIST/ASTRONAUT AND THE PI WILL PERMIT EXPLORATORY CHANGES TO BE MADE IN THIS FACILITY
 - THIS SYSTEM IS A SCALE VERSION OF A COSMIC RAY FACILITY PLANNED EITHER FOR A SPACE STATION EXPERIMENT MODULE OR A SHUTTLE-SERVICED SATELLITE

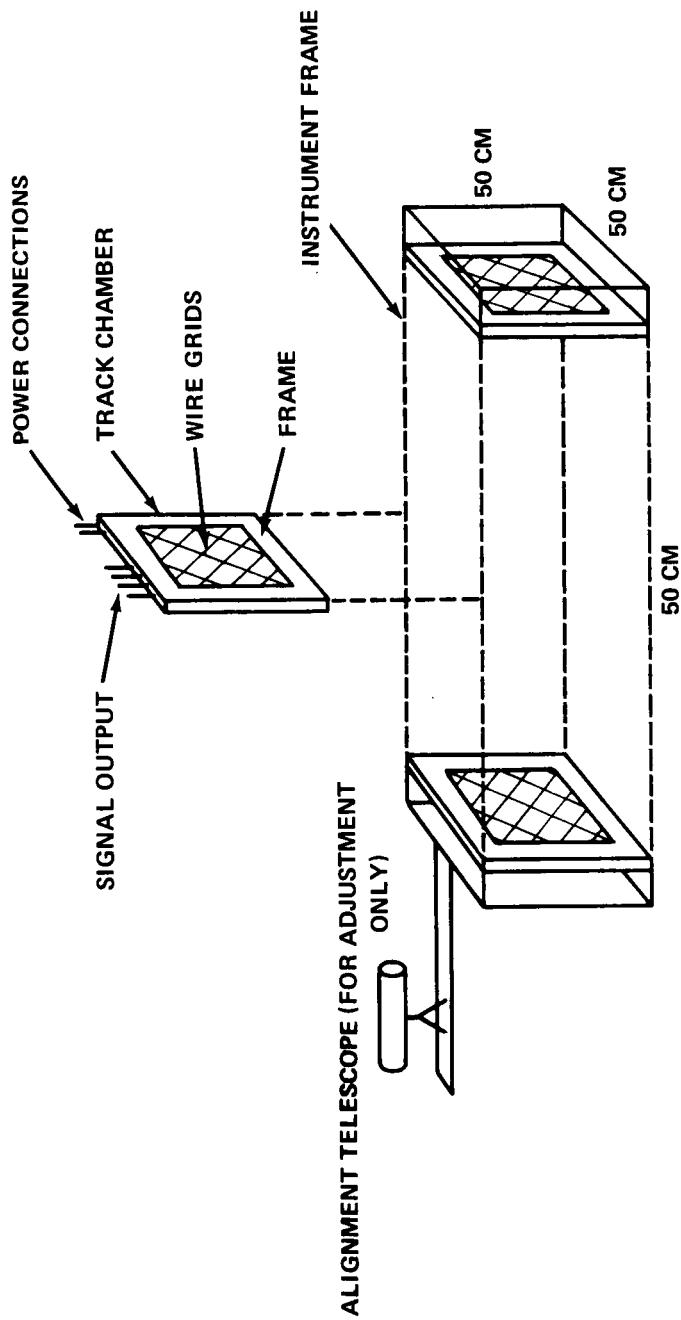
ELECTRON GAMMA RAY EXPERIMENT PLAN

The electron gamma ray experiment is considered a qualified experiment for Skylab B because it is capable of producing important science returns and it uses man. In addition, it has evolutionary potential both for the near term and for a second generation experiment.

This experiment is designed to explore a new energy regime of space radiation above the earth's atmosphere. Particle interactions with matter and radiation source phenomena (direction, flux, etc.) will be investigated.

In the task performance area, the intent is to use the crew for many of the same tasks a skilled laboratory technician would carry out in the final assembly, check-out, and operation of this experiment. A relatively simple task might be the installation of the crystal. Since this is a delicate item, it would be preferable to launch it in a protective package which would limit mechanical impact. Installation should be relatively simple since positioning tolerances are low. A more complex task involves the installation of the track chambers. This is illustrated in more detail in the following chart.

In terms of evolutionary potential, there may be appropriate changes such as instrument performance updating which could be accomplished during the course of the Skylab B mission. For the longer term, this instrument serves as a scale version of a cosmic ray facility which could be flown in conjunction with a Space Station or Shuttle.



EXPLODED VIEW OF 3 TRACK CHAMBERS MOUNTED IN FRAME

ASSEMBLY AND ALIGNMENT OF TRACK CHAMBERS FOR HIGH ENERGY FACILITY

MAJOR TASKS

COMMENTS

ASSEMBLY

UNPACK TRACK CHAMBERS
PLACE IN INSTRUMENT FRAME

CHAMBERS HAVE DELICATE WIRE GRIDS, WHICH
ARE PROTECTED BY COVERS
SPARE CHAMBERS SHOULD BE CARRIED

CONNECT SIGNAL AND VOLTAGE CABLES

CABLES ARE COLOR AND NUMBER CODED

CHECK RESPONSE OF TRACK CHAMBERS
AND DATA REDUCTION EQUIPMENT

A QUALITATIVE TEST FOR PROPER CONNECTION
USING A BETA SOURCE

FINE ALIGNMENT (A)

MOUNT ALIGNMENT TELESCOPE ON CHAMBER
FRAME. ALIGN CHAMBERS USING OPTICAL
TARGET AND SETTING SCREWS

A TEDIOUS TWO MAN PROCESS
AUTOMATION WOULD BE COMPLEX

FINE ALIGNMENT (B) (NO ALIGNMENT TELESCOPE)

TRIAL AND ERROR ALIGNMENT USING
SETTING SCREWS AND INFORMATION
FROM INSTRUMENT COMPUTER

A BACKUP TO (A). WITH MAGNET OFF, PARTICLES
SHOULD FOLLOW STRAIGHT LINES. NOT THE
PREFERRED MODE.

RECOMMENDATIONS AND CONCLUSIONS

- INSTRUMENT DESIGN
 - DESIGN MAN INTO THE EXPERIMENT SYSTEM
 - WHEREVER POSSIBLE TASKS SHOULD CONTAIN ALTERNATIVE PROCEDURES AND SEVERAL LEVELS OF COMPLEXITY WITH PARTIAL SUCCESS POSSIBLE AT EACH LEVEL
- PAYOUT LOAD SELECTION
 - IT IS DIFFICULT TO QUANTIFY PERFORMANCE (MOST TASKS NON-REPETITIVE)
THE DEFINITION OF TASK SUCCESS IS HIGHLY INSTRUMENT AND MEASUREMENT DEPENDENT
THEREFORE, PERFORMANCE DATA MOST CREDIBLE TO FUTURE EXPERIMENTERS
IS TAKEN ON EXPERIMENTS IN THEIR DISCIPLINE
IN VIEW OF THIS, A MULTIDISCIPLINARY PAYLOAD IS RECOMMENDED
- PRINCIPAL INVESTIGATOR/CREW INTERACTION
 - PREFLIGHT PLANNING AND TRAINING ARE ESSENTIAL
 - IN FLIGHT COMMUNICATIONS BETWEEN CREW AND PI DURING EXPERIMENT OPERATIONS
ARE HIGHLY DESIRABLE
 - POST-FLIGHT EXPERIMENT PERFORMANCE EVALUATION PROVIDES A VALUABLE INPUT TO
FUTURE EXPERIMENT PROGRAMS
- SKYLAB B COULD PROVIDE TASK PERFORMANCE DATA IN MOST MAJOR
EXPERIMENT CATEGORIES APPROPRIATE TO SSM AND SHUTTLE OPERATIONS
- OPPORTUNITIES EXIST ON SKYLAB A TO TEST THE PROPOSED SKYLAB B PAYLOAD PRINCIPLES

RECOMMENDATIONS AND CONCLUSIONS

Man's potential for space experiment task performance will not be realized until he is designed into the experiment system. As a point of departure for determining what level of interaction the man should have with any given experiment, an analogous ground-based experiment program provides useful guidelines. Wherever an experiment is found to be critically dependent on a particular task function, alternate procedures should be identified.

Task performance data is best defined in terms of the user. The user is, in fact, the total group of individuals who will be planning and carrying out the next experiment program for which the Skylab B instrumentation and tasks have meaningful analogs. An obvious example is a second generation version of the same instrument, but there are also useful analogs which cross disciplinary boundaries.

To use man effectively in the conduct of space experiments, crew performance must approach that of a good laboratory technician. When a large number of multidisciplinary experiments must be handled by an individual crew member, it is difficult to approach this training level. This factor is compounded by time requirements for training for flight operations. Until crew training for each experiment can be increased dramatically, real time support for each experiment from a PI group on the ground should be planned.

With a relatively small number of experiments on Skylab B, task performance data could be acquired which would provide the foundations for experiment program planning for all the experiment modes appropriate to both Space Station and Shuttle operations.

Finally, it is important to realize that there are experiments in the Skylab A payload which, with proper planning and little or no change to the hardware, could test the payload principles proposed for Skylab B. The example of the infrared spectrometer has been cited in the text. With proper selection of ground truth sites and a rating system based on visual discriminability, the capability of the astronauts to get the spectrogram on the target could be quantitatively measured. This is not to imply, however, that such effects could not be tested in a ground simulator. In fact, it is assumed that simulator training will have been carried out. The advantage of also taking in-flight task performance data is clearly the reality of the flight environment. However, acquisition of this in-flight data must be carried out in such a way that it does not compromise the objectives of the scientific experiment.

ISSUES

- REUSE OF FACILITY CLASS EXPERIMENT EQUIPMENT
 - EXAMPLES
 - ELECTRON GAMMA RAY EXPERIMENT
 - X - RAY TELESCOPE
 - MODES (SUBSEQUENT TO SKYLAB B CREW DEPARTURE)
 - UNMANNED OPERATION, WITH OR WITHOUT REVISIT
 - QUIESCENT STORAGE, REACTIVATION ON REVISIT
 - QUIESCENT STORAGE, RECOVERY ON REVISIT
 - REDUCTION OF EXPERIMENT COST AND LEAD TIME AS A GOAL
 - REDUCE PERFORMANCE AND TEST REQUIREMENTS
 - SIMPLIFY EXPERIMENT/SPACECRAFT INTERFACE

ISSUES

Experiment Equipment Reuse

The Skylab A mission will abandon the experiment payload when the astronauts finally leave the workshop. The actual experiment time will be far less than the useful lifetime of much of the equipment. A greater science return per unit cost of experiment instrumentation investment could be realized either if entire instruments or expensive components (such as the crystal in the electron gamma ray experiment) were recovered for future reuse or if the instruments were capable of operation after the Skylab crew abandoned the workshop.

Two of the experiments which, by our criteria, qualify for the Skylab B payload - the electron gamma ray experiment and the x-ray telescope - could be very expensive and should probably be operated as long term facilities. Before recommending these experiments for a planned payload, alternatives which could ensure long duration use should be explored.

Experiment Cost and Lead Time Reduction

One of the outstanding problems in the Skylab A experiment program has been high costs. These have been attributable to such factors as requirements for instrument reliability and, indirectly, the long lead time for development. Long lead times are also undesirable from the PI point of view because they freeze his instrument design years before the actual flight. While carrying out its primary mission objectives, Skylab B should also explore concepts for experiment cost and lead time reduction. For example, proper use of the astronaut for experiment tasks such as operation and repair could reduce reliability and test requirements (and, hence, development costs) without compromising the scientific objectives. New design concepts which simplify (minimize) the experiment/spacescraft interface could reduce experiment development lead time requirements.

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APPENDIX

OTHER EXPERIMENTS CONSIDERED FOR SKYLAB B

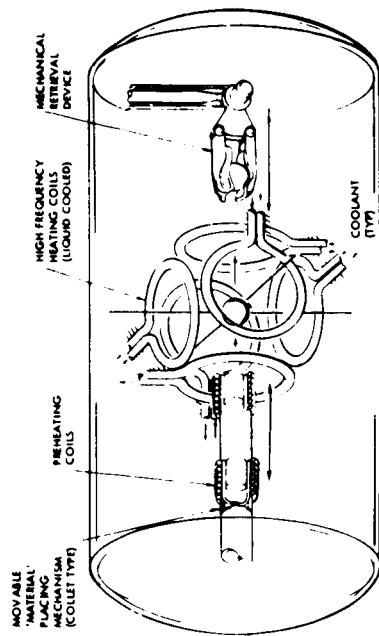
MATERIALS PROCESSING

X-RAY TELESCOPE

IR SPECTROMETER

MATERIALS PROCESSING EXPERIMENT

SAMPLE POSITION CONTROL DEVICE, MELTING AND STIRRING TECHNIQUE



- SAMPLE CONSISTS OF TRANSPARENT GLASS CONTAINING SMALL BEADS OF OPAQUE MATERIAL
- GLASS IS DOPED TO REDUCE ELECTRICAL RESISTANCE
- INDUCTION COILS USED TO MELT SPECIMEN, CONTROL ITS POSITION AND STIR
- PREHEATING RESISTANCE COILS MAY BE REQUIRED TO FURTHER REDUCE RESISTIVITY OF GLASS
- PHOTOGRAPH MOTION OF BEADS RESULTING FROM STIRRING MOTION OF INDUCED FLUID CURRENTS
- PHOTOGRAPHY ALSO RECORDS SENSITIVITY OF POSITION CONTROL AND BEHAVIOR OF LIQUID DROP (e.g., OSCILLATIONS)

MATERIALS PROCESSING

AN EXPERIMENT DESIGNED TO ILLUSTRATE THE SKYLAB B PAYLOAD PRINCIPLES IN CONTRAST TO THE SKYLAB A MATERIALS PROCESSING EXPERIMENT

SCIENCE RETURN

- EMPHASIS ON DEVELOPMENT OF PROCESSING TECHNIQUES RATHER THAN ON THE MANUFACTURE OF SPECIFIC ITEMS (E.G., BALL BEARINGS, GaAs SINGLE CRYSTALS)

THESE INCLUDE

- TRANSPORT AND CONTROL OF LIQUIDS, SOLIDS AND GASES
- STIRRING TECHNIQUES
- HEATING AND COOLING TECHNIQUES
- PHYSICAL PROCESSES CAN ALSO BE INVESTIGATED IN 0-G
- SURFACE TENSION
- BOILING AND SUBLIMATION

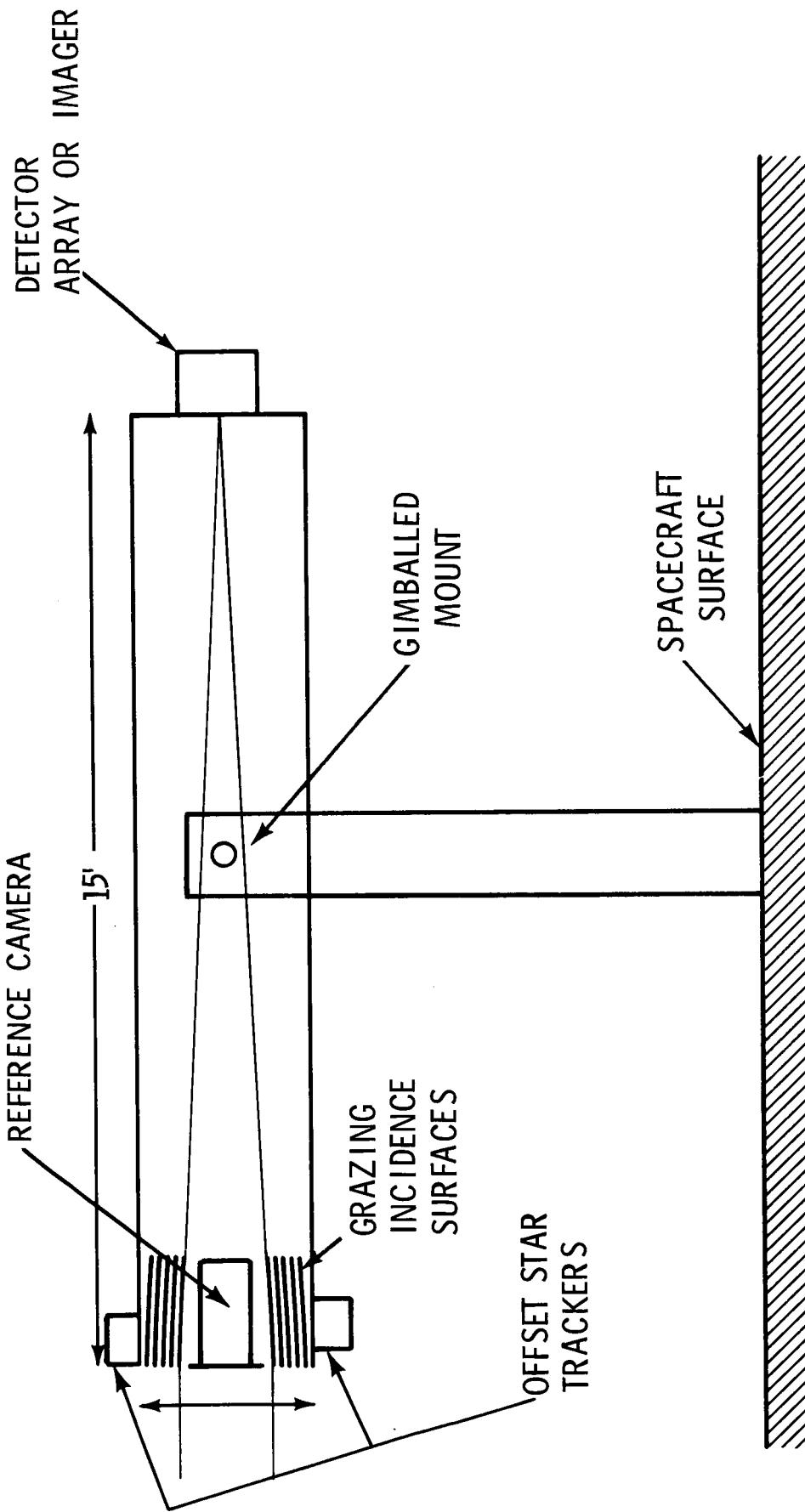
USE OF MAN

- THE SCIENTIST/ASTRONAUT WILL ASSEMBLE, OPERATE, DISASSEMBLE AND STORE THE DEVICES, AS WELL AS TAKE DATA
- IN COOPERATION WITH THE GROUND-BASED PI HE WILL "EXPERIMENT" WITH THE INSTRUMENTS, I.E., HE WILL MAKE REAL TIME CHANGES IN THE PLAN TO REFLECT HIS EXPERIENCE

EVOLUTIONARY POTENTIAL

- THE ULTIMATE GOAL IS THE VALIDATION OF MANUFACTURING PROCESSES WHICH COULD BE USED IN SPACE ON A LARGE SCALE (E.G., ON A SPACE STATION)

GRAZING INCIDENCE X-RAY TELESCOPE CONFIGURATION



THE X-RAY TELESCOPE SYSTEM

SCIENCE RETURN

- LOCATION OF X-RAY SOURCES TO 1-2 ARC SECONDS
- IMAGES OF EXTENDED X-RAY SOURCES
- HIGH RESOLUTION SPECTROSCOPY
- POLARIMETRY

USE OF MAN

- SINCE THE TELESCOPE MUST BE OUTSIDE THE SKYLAB B
SPACECRAFT, EVA IS NECESSARY. THE ASTRONAUT WILL
BE REQUIRED TO:

- a) REPLACE DETECTORS
- b) HANDLE FILM
- c) MAKE SIMPLE REPAIRS

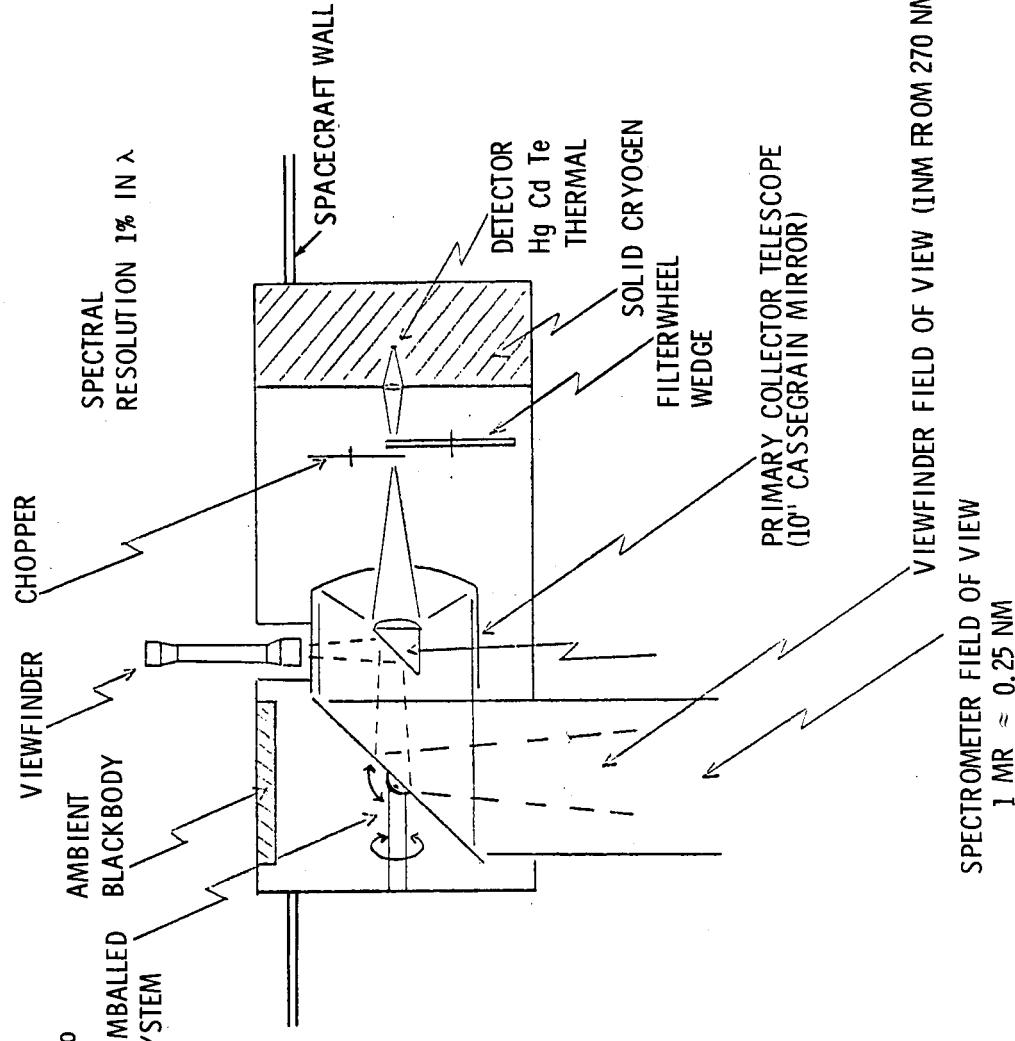
EVOLUTIONARY POTENTIAL

- THE ULTIMATE GOAL IS TO PLACE AN X-RAY TELESCOPE IN
A FREE-FLYING MODULE AND SERVICE IT FROM A SHUTTLE

INFRARED SPECTROMETER FOR EARTH RESOURCES

SCAN TIME 1 SEC
WAVELENGTHS 0.4 - 2.4 μ
 6.2 - 15.5 μ

SCHEMATIC OF POINTING/TRACKING SYSTEM (MARTIN MARIETTA, DENVER)



INFRARED SPECTROMETER

A SKYLAB A EXPERIMENT WHICH COULD ILLUSTRATE THE SKYLAB B PAYLOAD PRINCIPLES

SCIENCE RETURN

- MEASURE ABSORPTION SPECTRA TO OBTAIN ATMOSPHERIC ATTENUATION FOR SURFACE TARGETS AND CONSTITUENT PROFILES FOR METEOROLOGY
- EVALUATE THE EARTH RESOURCES EXPERIMENT PACKAGE CAPABILITY IN THE VISIBLE AND IR TO IDENTIFY AND DESCRIBE GROUND TARGETS

METEOROLOGY – STUDY OF MESOSCALE PHENOMENA (10-100 KMS) AND ENERGY TRANSFER ($6\text{-}16\mu$)

AGRICULTURE – HIGH RESOLUTION SPECTRA OF CROPS AND VEGETATION ($0.4\text{-}0.9\mu$, $6.2\text{-}14\mu$)

OCEANOGRAPHY – SEA SURFACE TEMPERATURES ($\pm 1^\circ\text{K}$) CHLOROPHYLL CONTENT OF WATER ($0.4\text{-}0.6\mu$)

USE OF MAN

- THE MAJOR TASK IS TARGET ACQUISITION. THIS PROVIDES A CONTINUUM OF TASK LEVELS BASED ON THE DIFFICULTY IN ACQUIRING THE TARGET

EVOLUTIONARY POTENTIAL

- THE ACQUISITION AND TRACKING SYSTEM CAN BE USED IN LATER EXPERIMENTS TO ACQUIRE AND PHOTOGRAPH BARIUM CLOUDS, TRANSIENT EVENTS ON THE EARTH SUCH AS AURORAE AND SEVERE WEATHER CONDITIONS, AND TARGETS FOR THE DOD
- THE SKYLAB MISSION CONSTITUTES PART OF THE DEVELOPMENT PHASE OF THE EARTH RESOURCES EXPERIMENT. IF THE EXPERIMENT IS PROVEN OUT, THE OPERATIONAL PHASE SHOULD BE CARRIED OUT ON A SATELLITE FOR LONG TERM OBSERVATIONS OR THE SHUTTLE FOR SHORT TERM (<2 WEEKS) OBSERVATIONS.